

IRBY — Genes From A Chemical Point of View



The Biologist



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CHAPTER NEWS NUMBER

Phi Sigma

BIOLOGICAL HONOR SOCIETY

"The object of Phi Sigma is to promote interest in biological research. Although originally designated as an honorary biological research society, it should now be considered as a working guild of biologists interested in research. In effect, election to Phi Sigma should be an opportunity for better work, rather than merely election to an honorary society."

Mile Posts:

- 1915 March 17, Alpha Chapter organized, Ohio State University, Columbus.
- 1916 May, Central Governing Body organized, BIOLOGIST first issued.
- 1917 June, last War-time BIOLOGIST issued.
- 1921 February, BIOLOGIST revived.
- 1924 December, First National Meeting, Constitution revised, Washington, D. C.
- 1925 December, Second National Meeting, First Science Program, Kansas City.
- 1926 December, Third National Meeting, Second Science Program, Philadelphia.
- 1927 December, Third Science Program, Nashville.
- 1928 December, Fourth National Meeting, Coat-of-Arms adopted, Fourth Science Program, New York.
- 1930 January, Council Meeting, Ritual Revised, Norman, Okla.
December, Fifth National Meeting, Fifth Science Program, Cleveland.
- 1931 Phi Sigma Letters Registered, U. S. Patent Office.
- 1932 December, Sixth Science Program, Atlantic City.
- 1933 June, Sixth National Meeting, Seventh Science Program, Chicago.
- 1935 December, Seventh National Meeting, Eighth Science Program, St. Louis.
- 1937 December, Eighth National Meeting, Ninth Science Program, Indianapolis.
- 1939 December, Ninth National Meeting, Tenth Science Program, Silver Anniversary, Ohio State University, Columbus.

Expansion:

The Constitution provides that: "An active chapter may be established in any institution of learning which requires for graduation the equivalent of four years of collegiate work, and which is equipped with facilities for research work. - - - Any petitioning group must be active for at least one year before it may be granted a charter."

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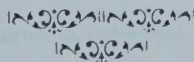
Contents

SPECIAL FEATURES

Genes From a Chemical Point of View	87
Ruth C. Irby	
Can We Control Growth?	96
Dr. Henry H. Collins	
Pittsburgh's Conservatory	102
Adolphe F. DeWerth	
Frogs	104
W. F. Swanson	
Demonstrating Capillaries and Diapedesis	106
Major Anselm M. Keefe	
The Mating of A Helioconid Butterfly	107
Walter Sweadner	
Southwestern Hordeae	108
Charlotte Goodding	

REGULAR FEATURES

Chapter News Letters	111
Book Review	115
Advertising	Back Cover



Directory

OF ALL ACTIVE AND INACTIVE CHAPTERS

*The list of chapter officers for this school year will be found in the
CHAPTER NEWS section of Vol. XXII, No. 1.*

ALPHA

Ohio State University, Columbus, Ohio, founded March 17, 1915, (Inactive).

BETA

University of Michigan, Ann Arbor, Michigan, founded June 3, 1916.

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University of Maine, Orono, Maine, founded January 27, 1917, (Inactive).

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University of Denver, Denver, Colorado, founded March 5, 1917.

ZETA

University of Wisconsin, Madison, Wisconsin, founded May 30, 1917

ETA

University of Akron, Akron, Ohio, founded April 20, 1921.

THETA

Michigan State College, East Lansing, Michigan, founded April 9, 1921, (Inactive).

IOTA

Washington University, St. Louis, Missouri, founded May 28, 1921.

KAPPA

University of Kansas, Lawrence, Kansas, founded May 31, 1921.

LAMBDA

Montana State University, Missoula, Montana, founded May 4, 1921.

MU

University of California, Berkeley, California, founded April 27, 1922.

NU

Washington and Jefferson College, Washington, Pennsylvania, founded May 11, 1922.

XI

University of Nebraska, Lincoln, Nebraska, founded May 3, 1934, (Inactive).

OMICRON

University of North Dakota, Grand Forks, North Dakota,
founded May 26, 1924, (Inactive).

PI

Emory University, Georgia, founded January 3, 1925.

RHO

University of Illinois, Urbana, Illinois, founded March 28, 1925.

SIGMA

University of Florida, Gainesville, Florida, founded December 4, 1925.

TAU

Duke University, Durham, North Carolina, founded March 4, 1926.

UPSILON

Miami University, Oxford, Ohio, founded May 7, 1926.

PHI

University of New Hampshire, Durham, New Hampshire, founded May 21, 1926.

CHI

Montana State College, Bozeman, Montana, founded February 11, 1927.

PSI

University of Washington, Seattle, Washington, founded April 7, 1928.

OMEGA

University of Oklahoma, Norman, Oklahoma, founded March 24, 1928.

ALPHA ALPHA

University of Southern California, Los Angeles, California, founded May 17, 1930.

ALPHA BETA

Mount Union College, Alliance, Ohio, founded May 17, 1928.

ALPHA GAMMA

University of South Dakota, Vermillion, South Dakota, founded May 15, 1928, (Inactive)

ALPHA DELTA

Lawrence College, Appleton, Wisconsin, founded March 7, 1929, (Inactive).

ALPHA EPSILON

University of Pittsburgh, Pittsburgh, Pennsylvania, founded March 23, 1929.

ALPHA ZETA

College of William and Mary, Williamsburg, Virginia, founded April 19, 1930, (Inactive).

ALPHA ETA

Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma,
founded March 13, 1930.

ALPHA THETA

State College of Washington, Pullman, Washington, founded May, 1930.

ALPHA IOTA

Bucknell University, Lewisburg, Pennsylvania, founded January 9, 1932.

ALPHA KAPPA

Hunter College, New York City, founded January 8, 1932.

ALPHA LAMBDA

University of Utah, Salt Lake City, Utah, founded February 13, 1932.

ALPHA MU

University and State College of Oregon, Eugene-Portland-Corvallis, Oregon,
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ALPHA XI

Rhode Island State College, Kingston, Rhode Island, founded May 17, 1935.

ALPHA OMICRON

Marquette University, Milwaukee, Wisconsin, founded June 18, 1938.

Genes From a Chemical Point of View

RUTH C. IRBY*

Through all ages man has sought, and is still seeking, the ultimate basis of life. Aristotle, in an attempt to explain the transference of life and likeness from parent to offspring, formulated a theory in which he regarded what we call the fertilized ovum as possessing potentially the functional capabilities of the parents, and development as being the actualization of these potentialities. Resemblance between parent and offspring was a consequence of their starting out with the same potentialities; it could not be explained as a particulate inheritance due to the transference of material particles.

The first understanding of the essential facts about reproduction became possible about the middle of the 19th century. Until the conception of the cell theory, until the facts of organic continuity became manifest, until the egg and spermatozoon were recognized to be cells, until the behavior of the chromosomes in maturation and fertilization had been followed, the basis for the modern ideas about development and heredity did not exist. The development, however, of these ideas left the way open for an explanation of heredity in terms of transmission from germ cell of the essential potentialities

of development. Darwin had formulated an atomistic conception of heredity upon which Weismann, in 1902, enlarged, to arrive at his germ plasm theory. This theory and the physiological and morphological fields for investigation that it opened added greatly to our knowledge of inheritance, though parts of Weismann's hypothesis were proved incorrect as the volume of information concerning the subject increased.

It remained for Sutton to draw first the parallel between cytological facts and Mendelian results. As Morgan (1910) carried out and interpreted his extensive breeding experiments with *Drosophila*, he utilized and extended Sutton's conception that Mendelian inheritance is bound up with the distribution of the chromosomes in reduction. Thus he was led to propose the gene theory in which he considered genes to be detachable and movable material units. As would be expected, many theories as to the structure of genes have been advanced. Highly important and most plausible among these proposed explanations are the theories that genes are complex molecules of chemical substances. To facilitate an understanding of the chemical theories of the gene, it is desirable to go back one step and review that which is

* Omega Chapter.

known concerning the chemical properties of chromatin and chromosomes.

In 1868, Miescher, after dissolving the cytoplasm from the more resistant nuclei of pus cells, studied the chemical composition of these important components of cells. He obtained a precipitate which contained phosphorus and responded to protein color tests. This substance, which Miescher called nuclein, was the first member of what is now a comparatively large class of substances obtainable from the nuclei of all animal and plant cells. Kossel then contributed to the knowledge of the chemical composition of nuclein. He isolated from it two purine bases, guanine and adenine. In 1887, Altman, a histologist, took a long step forward when he succeeded in isolating from nuclein an organic acid which was free from albumin and contained 8.9% phosphorus. A discussion of the chemical properties of this acid, nucleic acid, is also essential for an understanding of the problem at hand.

The nucleic acids studied have been obtained mainly from either the thymus gland or sperm or from yeast, the two former being taken as representative of nucleic acids of animal origin, the latter of plant origin. Upon hydrolysis all nucleic acids yield phosphoric acid, a carbohydrate, two pyrimidine bases and two purine bases. It is possible that these components may combine in different ways. Nucleic acid may exist in an open chain structure as suggested by Levene or it may exist in one of several possible closed chain structures (Wrinch 1937.)

It was once thought that nucleic acid was to be found only in the nuclei of cells. None was found in mammalian red blood cells, and little in muscle cells, but it was abundant in red blood cells of birds, in the thymus gland, etc. Recently Caspersson and Schultz

(1939) have found pento-nucleic acid in the cytoplasm of growing cells. This observation will be considered later.

Waddington (1939) pointed out facts which suggest a connection between nucleic acid and protein in chromosomes. He wrote, "Nucleic acid forms fibers and X-ray studies have shown that these consist of a chain of phosphoric acid residues to the side of which are attached a series of flat, plate-shaped groups each of which contains a purine base attached to a sugar. The repeat distance along the chain is 0.336 $m\mu$ for nucleic acid and 0.334 $m\mu$ for the polypeptide. This suggests a fact, actually observed by Astbury, that the polypeptide chains unite parallel to one another to give a protein-nucleate chain."

The distribution of nucleic acid in the nucleus can be investigated by means of ultra-violet spectroscopy. During division stages, when the chromosomes are contracted and can be seen as separate bodies, almost all the nucleic acid is attached to the chromosomes. Since interphase chromosomes are not distinct there is no clear evidence showing whether or not nucleic acid is thus concentrated during the resting stage. Be that as it may, the close association or identity of nucleic acid and the dividing chromosomes is significant. Interesting is the fact that virus activity is correlated with the presence of high molecular weight nucleoproteins. (Stanley 1940) Viruses, like genes, reproduce in living systems and mutate. Waddington (1939) reported that Koltzoff was unable to demonstrate nucleic acid in one stage in the development of the so-called "lamp brush" chromosomes in amphibian oocytes. If substantiated, this constitutes an important discovery.

The other constituent, which, with nucleic acid, makes up chromatin, is

protamine. As an example of this class of substances, I shall describe salmine, a protamine isolated from ripe salmon sperm. Evidence indicates that it is a polypeptide containing twenty-one amino-acid residues and twenty peptide linkages. It contains fourteen molecules of arginine, three molecules of proline, three molecules of serine, and one molecule of valine. Thus we see that this protein component of chromatin is very complex.

Waddington (1939) described two types of proteins, one in which the molecules are arranged in linear chains and one in which the molecules seem to be globular rather than elongate. In as much as the size of the chromonema is concerned, chromosome proteins may be either fibrous or globular. Fibrous protein in a polypeptide chain can be stretched only by actual straining of the chemical bonds. Globular proteins probably exist in a folded configuration, so that stretching of the fiber can proceed much farther without rupture. Chromosomes can be stretched from two to three and one-half times their original length. This fact suggests that chromosome protein may be globular. It may be noted here that Picken (1939) wrote, "Schmidt (1937) emphasized the parallel between the high elastic extensibility of the sodium alpha thymonucleate gel and that of the chromatin threads of spermatocytes—and concluded that the properties of nucleic acid jelly make it certain that many of the optical and mechanical properties of the chromatin of the nucleus are due to its nucleic acid component."

As already noted, chromatin appears to be almost exclusively composed of protamine nucleate, a protamine combined with nucleic acid. The available evidence points either to a true salt formation or to a coacervate system.

Nucleic acid forms at least 40% of the solid components of chromosomes. It may, therefore, be of importance in heredity.

We are now prepared to discuss the fundamental question with which this paper is to deal. What is a gene? Is it a locus, a material particle, an active molecule, a group of molecules, or does the gene really exist?

Goldschmidt (1938) listed the following characteristics of a gene.

- (1) It is a highly reactive substance, and is potent in very small quantities.
- (2) The substance of the gene is doubled before each cell division: it is therefore capable of assimilation and growth.
- (3) The gene is able to undergo a definite, sudden and, in many cases, reversible change, called mutation.
- (4) The mutated gene is perpetuated in the same way and is as stable as the original gene up to the moment of another mutation.

The gene behaves as a unit in heredity. This fact led early geneticists to consider the gene as a detachable particle, possibly one or more molecules of a substance. Morgan (1917) wrote "—germ plasm is made up of independent pairs of units."

Since only protein molecules approximate the properties of genes, it is important to show that the size of the gene is of the order of magnitude of these molecules. Muller (1928) calculated the gene number in the chromosome from Zeleny's and Sturtevant's data on the frequency of crossing over of the Bar gene with itself. Gowen (1933) taking advantage of the fact that X-rays impinging on cell chromatin cause heritable changes at multiple foci and that the rates at which these

changes are produced are proportional to the X-ray dosage given, noted the frequency of mutation and calculated the probability of single hits. He found the minimum number of loci (genes) is 1,280 for the X-chromosome. The ratio of material containing genes found in the sex chromosome as compared with the autosomes is 32.4%. The number of genes in the autosomes can, therefore, be calculated. Gowen gives 13,100 as the number of genes in the autosomes of *Drosophila*. The size of the gene may be calculated from these data. The actual size, computed from the size of the chromosome is 10^{-6} cm. Gowen believes this would allow for something like fifteen protein molecules. Blackwood (1931) estimated the diameter of a gene from the comparison of the number of gene changes with the number of ions produced by a given X-ray dosage. Since it is now known that chain molecules exist having a magnitude of 800 to 1000A, calculations of the kind given above are not so significant.

An attempt to build up a chromosome from chemical units leads to a scheme of linear arrangements of units of different orders of magnitude. Waddington (1939) postulated the nature of these units thus: "The ultimate units are the links in a polypeptide chain with a length of only 0.334μ . Exactly what the larger units are is more doubtful but there is a range of possibilities; there are periodicities along the chains, the repeat units out of which protein crystals are built; there are the protein molecules such as they exist in solution; and finally there are virus particles, all of which may be considered as providing sug-

gestions as to the kinds of units which may be involved."

Waddington continued, "Certain properties of genes give some hint as to the possible kinds of units which fill the gap between the 0.334μ polypeptide link and the $100\text{ m}\mu$ gene. Most important is the property of identical reproduction. Between two cell divisions, each gene causes the formation of another gene exactly like it; if the gene mutates, it is the mutated gene which is reduplicated. The gene must in some way act as a model on which the new gene is formed. This can occur only if forces originating in the radicals in the gene can extend far enough to influence the nature of radicals formed in the equivalent places in the new gene." Studies show this could be the case. It is necessary, however, to find some mechanism which accounts for the fact that only two genes, the old one and the new one, are present at the end of each intermitotic period. No plausible hypothesis to account for this has been advanced.

If the gene is one or more molecules of a substance, there are a number of possibilities for explanation of the process of mutation. I shall discuss some of those considered important at the present stage of chemical knowledge.

First we may briefly consider Goldschmidt's early theory that a mutation is a change in the quantity of the gene.* From the fact that there is a difference of action between one and two sex-determining genes, from the intermediate conditions found, showing that an orderly series of effects exists between the action of one and two genes (intersexuality), from multiple allelomorphs and other facts, Goldschmidt found basis for his theory. Facts brought to light by his more

* Plan or organization and some of the facts used in this section of the paper were taken from R. Goldschmidt's *Physiological Genetics*. McGraw-Hill, 1938, pp. 282 et. seq.

recent investigations as well as facts discovered by other workers in the field have, however, caused Goldschmidt to alter his views. These views will be considered later.

Another conception of mutations, which of course involves another theory as to the structure of genes, is the hypothesis that mutations are changes in side chains or residues. This idea was first presented by Correns (1919) as a result of studies on unstable genes. He described instability as a disease of genes and assumed that the gene consists of a large molecule to which the same side chain of atoms is attached.

From the same body of facts Demerec derived a related theory of gene mutation. In a 1939 paper he summarized his conception of the gene as follows: "Chromosomes may be visualized as composed of two components: (1) of fiber-like chromonemata which are structurally similar throughout the whole chromosomal complex and (2) of materials linked to the chromonemata, which differentiate various sectors of a chromosome into units called genes. This picture has a close counterpart in the structure of the fiber protein molecules outlined by Astbury and Bell. The backbone of the protein molecule may correspond to the fundamental unit of a chromonema, and a group of radicals attached to the backbone may correspond to the gene." Although the chemical make-up of the protein molecule is not fully understood, it contains polypeptide links having —CO—CHR—NH . R (the side chain) may be a single hydrocarbon, an alcohol, or a base such as agrinine. Radicals rich in nucleic acid are associated with genetically active regions of the chromosomes. Waddington (1939) wrote, "It appears not unlikely that nucleic acid plays

some important role in gene reduplication. Most rapid synthesis of nucleic acid occurs just before the prophase of mitosis at a time when the chromosome appears to split or reduplicate."

Demerec considered that the activity of genes is determined by three internal factors, namely: chemical composition of the gene, genetic constitution of the gene system in which it acts, and the position of the gene in the gene system. This last point will be considered again as we proceed.

Were the gene a molecule, a mutation might arise through the formation of stereoisomeres. There is, however, no proof for this explanation. Goldschmidt calls attention to the chemical fact that the stereoisomeres of the male sex hormone have no hormonal effect at all whereas many of the isomeres of the female hormone act alike. This example shows that it would be difficult, on this basis, to explain genetic facts in simpler terms.

Alternatively, and in opposition to the view that the gene is a single chemically active molecule, it may be assumed that the gene is a compound consisting of a number of identical sub-units or sub-genes of different, separable parts. In this case, reproduction might continue gradually and the gene form until it eventually divides into two by the reaction of some instability which increases with increasing size. The difficulty with this hypothesis is the fact that some genes show more or less equal rates of back and forward mutations. Serebrowsky, whose ideas were based upon the case of a step allelomorphism in the scute series of allelomorphs in *Drosophila* and Thompson, who derived his theory from a study of the Bar locus in *Drosophila*, were the chief supporters of this view. New discoveries relate the scute locus to position effect and Bar has been

proved to be a duplication of a chromosomal segment; so this theory has lost much of its value.

Thus far we have discussed the conceptions concerning the chemical structure of genes, if genes are independent units attached to the chromosome at definite loci. The gene may be a part of a higher unit. Muller (1932) called attention to interactions of genes within a chromosome as distinguished from those between genes in different chromosomes.

The theory that the chromosome itself is a giant molecule, the side chains of which represent the genes, was advanced by Castle (1919) and Renner (1920) and elaborated by Koltzoff (1928). Koltzoff's ideas as summarized in Goldschmidt's *Physiological Genetics* follow. To Koltzoff the chromatic thread representing the gene string of other authors was either a very long protein molecule or a bundle of such molecules around which new molecules are assimilated from the surrounding chromatin mixture, so that the bundles grow and may divide. Different radicals have a definite position and all chemical changes in these radicals will appear as mutations. Bringing his ideas in line with recent developments in chemistry, Koltzoff (1935) stated that the chromonema is a chain molecule (or micella composed of such molecules) containing protein and other radicals, the genes. Genes attract their like from the surrounding solution and synthesize them.

To Wrinch (1934, 1936) chromosomes were molecular aggregates. In 1934, she wrote, "In view of recent advances in our knowledge of proteins, it is reasonable that an attempt should be made to see how far the properties of chromosomes and the facts of genetics may be brought into relation with certain known facts of protein

structure." Starting with the protein molecule, she pointed out the fact that the molecule is built of amino-acid residues and that the active proteins have a high diamino acid content. Clupeine, which she took as a model, consists of long chain molecules in which arginine residues alternate with certain monoamino acid residues. There are 28 residues and the length of the chain is 98 Å. These molecules, linked by suitable bonds, form the protein pattern of the chromosome and a bundle of them constitutes a chromosomal micella. A change of the chromosomal pattern would constitute a genetical difference. As she conceives it, this molecule possesses four negatively ionized centers which form basic compounds with the positive amino-acid residues. If these basic compounds are formed at all four centers, and if the chains within the micella are identical, the nucleic acid ions will completely encircle the micella. Thus she finds the proper place for nucleic acid in the chromosome. Wrinch assumes that a gene is a group of molecules between the natural breakage points.

According to Picken (1939), "Wrinch's arguments for an ordered micellar structure of chromosomes have been strengthened by the recent researches of Schmidt and his collaborators on the optical properties of chromatin in a great range of nuclei. Schmidt has pointed out that Wrinch's assumption that the chromosomes are bundles of polypeptide chains held together by transversely disposed nucleic acid molecules, is not reconcilable with the observed birefringence of chromosomes and of nucleic acid." From his studies Schmidt concluded that "the molecules of nucleic acid in the chromosomes lie parallel to the polypeptide chains."

Mazia (1940) investigated the relationship of protein and nucleic acid in the structure of salivary glands of *Drosophila*. He wrote, "Experiments with mixed nuclei demonstrated that Feulgen staining material may be digested without subsequent degeneration of the chromosome which could be demonstrated by the ninhydrin reaction. The composition of individual nuclei indicated that nucleolidase (alkaline phosphatase of the intestine) would alone produce these results. This is interpreted to mean that nucleic acid is attached to protein in the molecule through phosphoric acid residues of nucleotides. These results contradict the theory of Miss Wrinch."

Schultz and Caspersson, although not responsible for the formulation of a chemical theory of genes, have contributed some important facts. They studied cytoplasmic nucleic acids in an attempt to gain some evidence as to their role in the cell and their synthesis in relation to the nucleus. They found indications that cytoplasmic nucleic acids are of importance in growth and division and that their synthesis occurs at the nuclear membrane. They also revealed the fact that nucleic acid is in some way connected with the stability of the gene; for when parts of the inert region in *Drosophila* are translocated into euchromatic regions, the neighboring loci frequently become unstable and undergo somatic mutations. This is an example of the phenomenon called position effect.

Goldschmidt pointed out that "—different interpretations have been proposed to explain position effect without changing the concept of the gene. The important point is that it is generally assumed that the position effect has to be explained within the present gene theory, which remains unaffected as such."

The facts regarding position effect as well as facts derived from X-ray work bring us, Goldschmidt suggested, to a point where we must ask ourselves whether or not the theory of the gene as the hereditary unit of actual separate existence, is still tenable. Nor is Goldschmidt the only one who would raise this question. Stroer (1936) concluded as follows, "—it is possible to maintain the genes and their significance provided we do not start our theoretical assumptions from the genes, but from the organism itself. The genes must not be looked upon as physiological atoms of the organism, but as its products which play a part in its support and development."

"Let us assume," Goldschmidt wrote, "that the whole chromosome is a large chain molecule of complex arrangement. Each point in the chain has a definite meaning in the chemical properties and the reactivity of the whole. The wild type might be controlled by the whole chain as a unit. If the chain is intact and each residue in its proper steric position, the catalytic processes dependent upon this chain molecule occur in a way that leads to what is called wild type. Any change in the chain may disturb the normal interplay of the catalyzed reactions, and a deviation occurs which is called a mutation. These changes described in terms of chemical models may be of several types such as the difference of stereoisomerism; differences in the length of chains as they characterize for example, the different carbohydrates; the possibilities of a chain molecule composed of unequal links, the manifold combinations of which form related but different compounds." Goldschmidt (1933, 1940) listed facts obtained from the use of X-ray, temperature shocks, genetic experimentation, etc., which point in the direction of

the view of the nature of the germ plasm just described. In 1938, he stated that "—the chromosome is the actual hereditary unit controlling the development of wild type, that steric changes at the individual points of its length produce deviations which may be described as mutations, though no actual wild type allelomorph and therefore no gene exists." In 1940, being more thoroughly convinced that no particulate gene exists, he wrote, "The most general conclusion is that the entire recent development of genetics leads away from the classic theory of a particulate gene which reproduces itself and plays its own independent (though cooperative) role in controlling the process of development."

Bergmann (1937) has built up a model related to that proposed by Wrinch but different in that it no longer employs the concept of the gene. Bergmann and Neimann in their paper "New Biological Aspects of Protein Chemistry" give us these facts. Protein molecules are many-membered peptide chains of amino-acid residues. The structure of protein molecules is defined by a general stiochiometrical law. Each amino-acid residue of the peptide chain recurs at constant intervals. The total number of units in a chain is $288 (2^5 \times 3^2)$ or a multiple thereof. The synthesis of such molecules must be controlled by a specific chemical organizer capable of synthesizing the peptide bond and having ability to select a particular amino-acid or peptide at the correct moment, so that the unequivocal pattern of the complete protein molecule is adhered to at every stage of synthesis. Bergmann extended his idea thus: "The chemical organizer of each protein molecule must have the ability to promote hundreds of consecutive specific reactions, each of which alters the character of the substrate and thereby the character of the

subsequent specific reactions." This statement, it seems to the writer, embodies a very likely explanation of gene action in differentiation. The properties of a chemical organizer of proteins are to be found among intercellular proteinases which are capable of both hydrolyzing and synthesizing the protein molecules. The proteinase, responding to its surroundings, may produce its own replica, or may synthesize other proteins. Its structure, which is a complicated pattern of superimposed rhythms of different amino-acid residues, gives this proteinase its specificity. Any breakage or rearrangement in the chain leads to a destruction or impairing of the specificity and therefore to other reaction products, which may be assumed to control the phenotypic changes. Although Bergmann does not apply his ideas specifically to these concepts of biology, his findings make possible a reasonable hypothesis as to chromosomal structure, the nature of genes, mutations, and genic action in differentiation and determination.

In conclusion it may be stated that the chemical theories of genes have evolved from the early ideas that genes were molecules of protamine and nucleic acid localized in definite loci of the chromosome, to the conception that the gene as such does not exist. There are many alternative hypotheses but it seems most logical to the writer to believe that a gene, rather than being a definite unit, is a dependent part of the whole. The hypothesis set forth by Bergmann is logical and complete, affording a satisfactory basis for the formulation of future conceptions of the gene and the action of genes in differentiation.

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Can we control Growth?

BY HENRY H. COLLINS

"Living matter is potentially immortal—wherefore the biologist dreams of discoveries which will enable him to control growth and development, perhaps to extend the span of human life."

I

As the biologist observes a fertilized egg cell gradually developing through profound changes in size and form into an adult organism, he is confronted by one of the most challenging mysteries in the realm of science—that of growth and differentiation. The animal organism starts out as a small spherical mass of living substance, often of almost microscopic size—the fertilized egg arising from the fusion of an egg cell from the female and a sperm cell from the male parent. The organism in this stage of development is virtually a one-celled animal. Shortly, the cell divides and we have the two-cell stage followed by four, eight, sixteen-cell stages. Later our little mass of cells may assume the form of a hollow sphere. In some types the many cells of this stage are almost identical in appearance. This sphere may next collapse to form a somewhat hemispherical cup with a double wall of cells. This elongates to form a pouch-like structure. Our developing organism is now bilaterally symmetrical. We soon observe that, in further growth, the cells as they continue to divide and increase in number are becoming more and more unlike in different parts of the body. In other words, differentiation as well as increase in size is taking place. The biologists of former times were content to play the

role of onlookers. They merely described the various steps in the developmental cycle from the egg to the adult.

The modern investigator is not content to be a mere historian of the phenomena he observes. Like the child whose mind has not been ruined by educational malpractice, he wants to take the clock to pieces to see what makes it tick—to probe as deeply into developmental processes as possible with the hope of bringing the processes of growth and differentiation under control. His method of attack is experimental. He devises hypotheses concerning causal relationships and then devises experiments to test his hypotheses.

For example, a famous German biologist held that within the nucleus of the egg were ultramicroscopic determiners for all of the structures of the adult body. These determiners controlled growth and differentiation. When the egg cell divided and passed into the two-cell stage, the determiners for the right and left halves of the body were parceled out to these two cells; and this parceling out continued in the later divisions of the cells of the embryo until, ultimately, some cells had determiners only for brain tissue, others for bone, and so on.

Now it happens that in many kinds of embryos it is possible to separate

* Reprint from Pittsburgh Record, Dec. 1930, pp. 29-35.

the cells in the two-cell stage or even in the eight-cell stage. These isolated cells develop into complete animals. Then, too, in much later stages, in which the various organs are being formed, parts of the embryo may be interchanged (potential brain tissue with prospective skin) and each will develop in conformity with its new locality. These results advanced our knowledge of the problem of growth and development to the extent of eliminating an erroneous hypothesis.

II

Clues to causal relationships in growth and development have also been obtained by observing that a pathological condition of one structure is accompanied by disturbances in the development of other parts. Autopsies on human giants have revealed enlarged and tumorous conditions of the pituitary body, a small glandlike structure on the under surface of the brain. It is now known that this pituitary body throws off into the blood a substance which exerts a regulative effect on the normal growth of the bones of the skeleton and upon the reproductive glands. These, in turn, when fully developed, produce a substance or hormone which regulates the development of certain other parts of the body, the so-called secondary sexual characters, such as the beard and bass voice in man.

Atrophy of the thyroid gland in a young child results in arrested growth and deficient mental development, a condition known as cretinism. A person of twenty years may have the physical and mental development of a child of eight. If taken in time, the child may be caused to develop normally by the administration of extract of the thyroid from some animal such as the sheep. Similar results follow the grafting of a fragment of thyroid gland

from a healthy person or from an ape.

The influence of the thyroid gland upon growth and development has been studied in a number of lower animals. Tadpoles from which this gland has been removed fail to metamorphose into frogs, but become giant tadpoles. Tadpoles fed on extract of sheep thyroid metamorphose prematurely and produce miniature frogs no larger than a fly.

The thymus gland, located in the throat region near the thyroid, seems also to be concerned with growth, but in a quite different way. Removal of an animal's thymus may retard its growth, but at the same time accelerate its sexual development. Removal of the thymus also produces a softening of the bones similar to the condition in a case of rickets.

The pituitary body, a small rounded glandular mass about the size of a pea, extending from the under surface of the brain into the floor of the cranial cavity, has also been found to influence growth. The anterior lobe affects body size. Overactivity produces gigantism. Insufficiency results in dwarfing. Partial removal of the anterior lobe in experimental animals, such as the dog, produces a marked arrest in growth. Such an animal may be less than half normal size.

The germ glands, in addition to producing the egg and sperm cells, produce a hormone which plays an important role in regulating the growth and development of certain parts of the body—the so-called secondary sexual characters. It has been found, for example, that if in a mammal such as the rat or guinea pig, the male is unsexed and then the ovary from the female is grafted into his body, the rudimentary milk glands become enlarged and functional, and the skeleton grows to be like that of the female. Likewise, if the

ovaries are removed from young chicks they may develop the plumage, spurs, wattles, comb, and larger size characteristic of the male bird. It has long been known that when twins of opposite sexes occur in cattle, the female twin is in some cases sterile and much like the male in bodily form. It was discovered by Professor Frank Lillie that in such cases the blood vessels of the embryos fuse in such a way as to cause a mixture of the blood. The male germ glands normally develop at a somewhat earlier stage, and pour a secretion into the blood which inhibits the development of the female characters.

Recent experiments with dogs indicate that the wide differences between different strains are probably due mainly to differences in the system of glands producing the internal secretions. This has led to the suggestion that racial differences in man are susceptible of a similar interpretation. At present the members of one of the most progressive of the modern peoples of the world are greatly concerned because of their small stature. If one of their biologists were to discover a method of increasing their average height by a few inches, he would at once become a national hero.

III

Not only is the student of growth and development intrigued by the changes that occur from the egg to the adult, but he is also led to wonder why growth stops when it does. When an organism reaches what we are wont to regard as its normal size, growth ceases. Why? An interesting sidelight is thrown on this problem by studies of tissues grown outside the body. It has been found possible to keep small fragments of living tissue growing indefinitely in a sterile culture medium. Bits of embryonic chicken heart muscle

have been kept alive and growing for more than ten years. Although this tissue has been kept alive far beyond the normal life span it seems as vigorous as ever and there seems to be no reason for supposing it could not live and grow forever. Cessation of growth, old age, and even death seem not to be inherent in living matter. Living matter is potentially immortal. Such observations tempt the biologist to dream of discoveries which will enable him to modify growth and development and to extend the span of human life.

Relatively slight modifications of the normal chemical environment of the growing embryo may produce profound disturbances in its development. Stockard, an American biologist, subjected developing eggs of a common sea minnow to magnesium salts dissolved in sea water and found that a large percentage of the embryos developed a large single median eye instead of two normal laterally placed eyes. Similar Cyclopean monsters have been produced by treating frog eggs with lithium salts during certain critical stages in their growth.

In rare cases human twins are born whose bodies are more or less joined—so-called Siamese twins. Such double monsters result from some disturbance in the growth of the embryo at a very early stage. The fact that such twins are always of the same sex points strongly to the conclusion that they develop from a single fertilized egg cell.

Recent experimental studies on twins, double monsters, and other developmental abnormalities have shown that reduction of the oxygen supply plays an important role by causing arrest of growth of parts which are at the time in a critical and especially susceptible stage. In the normal growth of an embryo, at any given

time, certain parts are more actively growing and differentiating than are the remaining parts. In fact, the more actively growing parts appear to act as inhibitors to the growth of other parts. When growth of these parts is depressed by lack of oxygen or by other means, the more or less dormant portions of the embryo begin to grow more rapidly, and malformations result. In bilaterally symmetrical animals, dominant growth activity occurs along the linear axis of the body. If growth is decelerated along this axis by experimental means, one or more new growth points may appear and establish new axes.

By checking growth along the linear axes of fish embryos in different stages of development and for varying lengths of time, and thus inducing growth along secondary axes, Stockard has succeeded in producing a graded series of double monsters ranging from specimens with slightly separated heads and single bodies to those united only in the tail region. Where the Siamese fish twins are of equal size, both are normal in form, but in those cases where the twins are of unequal size the larger only is normal in form, the smaller being malformed, and its deformity varying according to the difference in size of the two components. Similar combinations occur in man, and the inducing causes are probably very similar. From the experimental work in this field it seems evident that, in the words of Stockard, "there are in the development of all or many organs certain periods at which those organs are peculiarly sensitive to any unfavorable condition which may act upon the embryo. Further, it may be emphasized that the peculiarly sensitive period is very close to the actual moment of origin of the organ in question. After an organ has arisen and passed through the earlier

stages of its development, it becomes less inclined to suffer radical modification in its manner of development as a result of unfavorable conditions. After it is completely formed, it is quite resistant."

IV

Another discovery which has grown out of experimental studies of growth in embryos is that the development of one part may condition that of other parts in a most remarkable way. For example, in a tadpole the greater portion of the eye, the so-called optic vesicle, grows out from the side of the brain until it comes in contact with the skin. The skin cells touched by the optic vesicle differentiate to form the lens. If this area of skin is removed and replaced by a skin graft from any other part of the body, the grafted skin will form a lens. Thus, the fate of a mass of cells in the body of an embryo is not wholly predetermined but, within limits, is due to its position and surrounding conditions.

The most epochal discoveries of the influence of one part upon other parts in embryonic development have resulted from the transplantation of tiny bits of tissue in very young amphibian embryos. A cell mass was discovered which acted, for a short time, as an "organizer," determining the trend of growth and development in the tissue surrounding it. When this "organizer" was transplanted from the head region, where it normally occurs, to the abdominal region, it induced there the formation of a second embryonic head with a rudimentary brain, out of cells which normally would have formed stomach, kidneys, and intestine.

Still another mystery that confronts the student of growth is manifested in the replacement or regeneration of lost parts. Certain types of starfishes

may literally be torn limb from limb, and each fragment will grow and form a complete and perfect individual. A salamander has had its tail removed eight times in succession and yet after each mutilation the tail has been regrown. This same animal is able to replace lost limbs in a similar fashion. One of the most interesting problems is why man and other higher vertebrates do not possess similar powers of replacing lost parts. The vermilion spotted newt which occurs in ponds in the Pittsburgh region possesses remarkable powers of regeneration of lost parts and is being used in experimental studies of regeneration in the laboratories of the department of zoology of the University of Pittsburgh.

We have seen that the fate of a mass of cells in any part of the body of an embryo is not altogether determined by the inherent properties of the cells, but by the environment in which it develops. This was shown by transplantation from one part of the body to another. In very young embryos the parts making up the body are very plastic; but as the embryo grows older and the adult condition is approached, there occurs a progressive loss of plasticity. This is demonstrated by transplantations of tissue in embryos of different ages. In some lower organisms the tissues of the adult body still possess a considerable degree of plasticity. This is manifested, for example, when an arm is amputated, and what is left of the biceps muscle proceeds to produce by a new out-growth and differentiation the muscles of the lower arm and fingers. From the bone left in the upper arm, the skeletal parts of the forearm and hand arise, and so on.

In some animals parts may be transplanted from one place to another in the adult body. In this manner the

degree of specificity possessed by cells of the various types in the adult body may be determined; or, in other words, we may thus ascertain how plastic the parts are, and to what extent it is true, even in the fully adult body, that the fate of cells is a function of their position. For this type of study the vermilion spotted newts are very favorable material. The under side of the body is a bright lemon yellow in color, marked with numerous black spots. The upper parts are very dark brown with vermilion spots, and the two areas are sharply marked off along the sides of the body.

The question arises: are these marked color differences due to specific differences of the cells composing the integumental tissues, or to other causes? Yellow skin may be grafted on a wound made by removing a patch of dark skin, and similarly, dark skin may be transplanted to the yellow under-surface of the body. For a long time the transplanted skin maintains its own characteristics in the new location, but slowly this transplanted bit of tissue assumes the appearance of the surrounding skin. Its growth is so modified that it finally loses its own peculiar characteristics. Parts, then, of an adult body may retain some plasticity; and the characteristics of cells are, in part, a function of their position in the body.

These results are quite in contrast with those of Harrison in his classic animal grafting experiment, in which the anterior half of a frog tadpole of one species was successfully grafted to the posterior half of a tadpole of another species of a different color. The tadpole lived and developed into a frog, but there was apparently no modification of the two halves, the line of union remaining quite sharp.

V

It has long been known that marked modifications of growth and development may be induced by cutting down the food supply. Professor Child found that by controlling nutrition in a simple flatworm he was able to control the processes of growth and aging. By partial starvations old individuals could be made to grow smaller in size and to become like young animals. An actual rejuvenescence was accomplished. A life cycle of three to four weeks was increased to more than three years. A human being under similar conditions would have a life span of about 2500 years.

Many of the experimental studies of growth may appear, at first sight, to be without rhyme or reason, but most of them contribute in some measure to our understanding of vital phenomena. From the very nature of research in what is sometimes spoken of as pure science, it is impossible to evaluate current work in terms of human welfare. However, the history of science is replete with examples of researches

which have been the means of revolutionizing human practical affairs, the significance of which was wholly unrecognized at the time.

One of the pressing human problems, towards the solution of which fundamental studies of growth and differentiation may well be expected to make a major contribution, is that of cancer. Normally any given mass of cells in the body realizes only such of its potentialities as are compatible with the well-being of the organism as a whole. A cancer is a cell mass which has somehow escaped from the growth regulatory mechanism; its growth runs riot. The cancer problem is fundamentally a problem of growth control, and it is significant that some of the leaders in cancer research are coming seriously to doubt that a solution of this problem will ever come from specific investigations of cancer. In their judgment, further progress awaits future discoveries which may be the outcome of fundamental researches on tissue growth and differentiation.



Pittsburgh's Conservatory

ADOLPHE F. DEWERTH—Consulting Horticulturist, Bureau of Parks.

Neighbor of two of Pittsburgh's great universities, on early fall mornings almost hidden by the smoke and fog from the mills and rivers below, stands the world-famous Phipps Conservatory, pervading beauty and quiet through an atmosphere of industrial strength and activity.

Confronted with the most adverse environmental conditions for good plant growth, the Conservatory today leads the world in outstanding exhibitions of floral beauty and horticultural development.

Forty-seven years ago, Henry Phipps, a leader in the development of the steel industry, built and presented the Conservatory to the City of Pittsburgh. There was at that time a gradual awakening of public interest in the growing and use of plants, and a desire on the part of the public to see how plants differed from one corner of the world to the other. And so the gift of these enormous greenhouses to the City at that time met with great public appreciation. For several years the Conservatory was pointed out to every visitor with pride.

The passing of years, new recreations and diversions, and a gradual period of decline and neglect of the Conservatory, caused it to fade from the interest and attention it should have commanded. This period of decadence continued until about seven years ago when the great possibilities of the Conservatory were again brought to notice by Ralph E. Griswold, then

recently appointed Superintendent of Parks. He interested several civic-minded leading citizens of Pittsburgh in the revival of this once-famous institution.

The united efforts of this group of citizens have culminated in the beauty now enjoyed by thousands of visitors.

The Conservatory covers approximately 115,000 square feet of floor area. It leads the world in free public flower shows. Visited annually by one-half million people, the largest daily attendance ever recorded was during the recent Chrysanthemum Show on Nov. 3, 1940, when 16,000 persons were counted.

And the Conservatory is rapidly taking its place as a prominent center of horticultural research and as an educational and cultural center of gardening. It is a perpetual interest for the plant lover, and its extensive plantings from every corner of the earth provide a garden for the thousands of city dwellers whose own crowded quarters do not permit them a garden of their own.

Through collaboration with the University of Pittsburgh, 136 students have completed courses in floriculture and several graduate students have conducted extensive investigations in plant growth which have led or will lead to advanced degrees.

A source of information in an infinite variety of subjects related to horticulture, botany, and amateur and professional gardening, the Conservatory serves as a clearinghouse for the

* In part a reprint of an article in *Pitt.*

plant problems of all the garden-minded people of the community. Plants are identified, questions on culture and plant pests are answered, sources of horticultural or commercial plant material are indicated, and research is constantly conducted on new developments so that anyone interested may know their effect on conditions in this vicinity.

Each year many lectures on subjects pertaining to the work and interests of the Conservatory are delivered by members of the staff and throughout the year conducted tours of the entire establishment are sponsored.

A personnel of four college graduates in botany and horticulture and one of the finest up-to-date scientifically constructed greenhouse ranges in the country make possible the most modern and scientific methods of plant culture.

Within recent years floriculturists all over the world have interested themselves in the study of the best methods to be employed in the germination of orchids from seed, and much scientific research at the Conservatory has been directed to this end. The practical application of scientific principles is very essential in this unusual type of reproduction and it is hoped to decrease the difficulties in germinating these plants from seed and to increase the hardiness of hybrid types. At the present time it requires seven years to produce a blooming plant

from seed; by varying the nutrient solutions, as indicated in the work at the Conservatory, it may be possible to shorten this period considerably.

Orchid hybridization has been a recent development and exact records have been kept so that all advances made with this family of plants is toward a definite end. Hybridization in this field is an excellent opportunity for research in the genetics of plant breeding as well as in other lines of plant culture.

Three ever-present needs in a large industrial city such as Pittsburgh are met by the Conservatory—the need for beauty, the need for education in the appreciation of growing things, and the need of scientific research into the problems of plant life.

To meet the need for beauty, especially, the display houses have been arranged, one by one, into garden effects or into natural forested areas; and although these displays are grouped more or less in taxonomic sequence for the student, effort has been made to present them so they will please the eye of the everyday visitor.

Orderly and peaceful, situated in a humming industrial center and in a world of conflict, this place has an intangible value of restful beauty which cannot be weighed or measured, yet its quiet significance can easily be realized and appreciated by a leisurely walk through its verdant paths.



Regeneration of Bone and Teeth in Frogs

W. F. SWANSON, M.S., D.D.S., University of Pittsburgh

Contrary to the general belief that the adult leopard frog, *Rana pipiens*, does not regenerate lost parts, the following experiment shows conclusively that regeneration can take place in this frog's maxillary region.

The sections removed, in each of the thirty-six experimental frogs, were approximately five millimeters long by two millimeters deep and included a portion of the maxillary bone and the teeth therein.

Histological sections cut in a plane horizontal to the excision show:

At forty-eight hours that the epidermis has grown over the cut edges

and become quite thick.

At fourteen days that resorption of the cut edges of bone has begun and that osteoclasts, fibroblasts, and many blood corpuscles are present.

At two months that a new tooth-germ is present in the regenerating tissue.

At four months that spicules of new bone are present in the regenerating area and new toothgerms are also present.

At five months that new bone spans the entire regenerating area and new toothgerms are present throughout.



ILLUSTRATION A SHOWS A FROG ONE DAY AFTER OPERATION.



ILLUSTRATION B SHOWS THE REGENERATION THAT HAS TAKEN PLACE
SEVEN MONTHS AFTER OPERATION.



Demonstrating Capillaries and Diapedesis

ANSELM M. KEEFE, St. Norbert College*

Capillary circulation has long been demonstrated to biology students by using the web between the digits of the frog. To do this requires quite a little preparation, particularly inactivating the frog. Even with the best of preparation the frog's foot is not the easiest object to keep under the high power lens of the microscope.

Despite the outstanding work of Drs. Eliot and Eleanor Clark at the University of Pennsylvania Medical School, the use of the frog tadpole for this purpose is only occasionally referred to in laboratory literature. At St. Norbert College we found tadpoles up to two centimeters long can be inactivated in a very weak ether solution and placed in the depression of a deep-cell culture-slide with the tail lying outside and to one side of the depression. Cover glasses can then be placed on the tail so that fairly high objectives may be used. Animals live for two or more hours depending on the rapidity with which the oxygen in the media is exhausted.

However, mature frogs or tadpoles are not available in ordinary laboratories for this demonstration all the year around. Neither are prepared slides of animal tissue demonstrating capillaries and their blood content by any means common in the price lists of laboratory supply houses.

Frog tadpoles up to three-fourths of an inch, total length, were killed in a stock 1:1:100 chrome-acetic solution. They were allowed to fix in this medium from 12 to 24 hours and then washed an equal length of time in tap water.

Bulk staining in Wright's blood stain, or in Mallory's connective tissue stain brought out variations in structures depending on the length of treatment. After staining, the tails are removed, run up into xylol and mounted under cover glasses in isobutyl methacrylate.

Not only are the more or less engorged capillaries distinctly demonstrable under low power, but the individual corpuscles can be rendered visible under high power. Particularly interesting in this regard are the white blood cells which can be distinguished in many positions, some within the capillaries, some in diapedesis on their way through the capillary walls, and some out in the surrounding tissue.

The fortunate accident that a vicious little five-spined stickleback (*Eucalia inconstans*) was kept in the same aquarium with the tadpoles resulted in many badly lacerated tadpole tails. In these the defensive aggregation of many white blood cells moving into the wound-area was particularly well demonstrated by either of the staining techniques mentioned.

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The Mating of a *Helioconid* Butterfly

WALTER SWEADNER, Erie Center

It has been generally known that the long-winged Butterfly *Heliconius charithonius* of Florida has a number of peculiar behaviorisms. It congregates in groups of a dozen or more to sleep, always in the same spot; it has a helicopter-like flight, being able to hover, fly forwards, backwards, or vertically at slow speed; it has peculiar mating habits. While making close-up movies of the latter, the writer observed a procedure, never before, to his knowledge, recorded.

In this species, mating takes place before the female has emerged from her chrysalis. The male seeks the chrysalis of the female, probably by sight, for the flight appears to be aimless searching, rather than the trial-and-error flights of those that search

by scent. Having found a chrysalis, the male alights head up and immediately turns head down so that his body is oriented with the chrysalis. As soon as the emerging female cracks open the head and wing covers of the chrysalis, the male places his abdomen over the junction of her abdomen and thorax in the back and applies pressure. As she begins to withdraw her thorax, the male's abdomen breaks through the shell and clasps the tip of her abdomen and actually forces it out of the chrysalis skin. This procedure was observed in three different matings and in each case, coition was complete before the emergence. The mating takes place in the early morning and the two remain together till evening, unless disturbed.



Southwestern Hordeae

CHARLOTTE GOODDING

The tribe HORDEAE contains all manner of grasses including important cereals, pasture and range grasses, and troublesome weeds many of which have been introduced into the United States from Europe and Asia. Though mainly grasses of temperate regions, there are numerous native representatives of this tribe in the southwestern United States, especially in its northern limits and in mountainous regions.

Over a year ago while working in the Rocky Mountain Herbarium at Laramie, Wyoming, the writer was assigned the task of checking over the genera of grasses in the cases. The genus *Agropyron*, Wheatgrass, was among the first of the grasses encountered. A great deal of confusion in the identification of species was evident. To bring order out of the chaos, work was begun and it furnished the stimulus for the continued study of all the HORDEAE.

In this study of the southwestern representatives much data on the economic aspects and on distribution was obtained from the Forest Service *Range Plant Handbook*, Hitchcock's *Genera of Grasses of the United States*, and Hitchcock's *Manual of the Grasses of the United States*.

The writer is indebted to Dr. Aven Nelson and Dr. C. L. Porter of the Rocky Mountain Herbarium in Laramie, Wyoming, for help and encouragement, as well as for the use of herbarium specimens; and to the Soil Conservation Service Nursery Section for the

use of herbarium specimens; and to her father, Leslie N. Goodding, for helpful suggestions throughout the study.

Members of this varied and important tribe may be distinguished from other grasses by the presence of the following characters: the spikelets which are one- to several-flowered are sessile on opposite sides of a zigzag, jointed, channelled rachis, forming in all cases 2-sided spikes. Another character is the presence of small projections (auricles) at the junction of the blade and the sheath.

An understanding of the modification of these general characters is important in recognition of the genera. Most obvious of these is the difference in the number of spikelets at the joint or node. In wheatgrass (*Agropyron*), Wheat (*Triticum*), and Rye Grass (*Lolium*) the number is typically one; while in Foxtail Grasses (*Hordeum*), Wild Rye (*Elymus*), and Squirreltail Grasses (*Sitanion*) the number is 2 or 3. The position of the spikelet on the rachis is either flatwise; that is, the outermost floral bracts (glumes) toward the outside away from the rachis; or edgewise, so that the glume is next to the rachis. All the genera except *Lolium* have the spikelets flatwise to the floral axis.

The rachis or floral axis may be continuous, that is, it may not break up when mature, or it may articulate into joints. The habit of shattering is especially typical of *Sitanion* and

Hordeum. Anyone who has tried to press or mount species of either of these genera has encountered this characteristic.

The rachis is usually flattened or concave next to the spikelets, but in some genera it is thickened with hollowed spaces, the spikelets being more or less enclosed in the hollows. This is true in the case of Goatgrass (*Aegilops*).

The glumes are likewise modified in several ways. The position of the glumes has already been mentioned. In *Lolium*, in which the position is edgewise, the glumes may be reduced to one, the rachis taking the place of the inner one. The glume shape varies from relatively broadly ovate to setaceous, there being many gradations within the tribe.

This small but important tribe of about 25 genera is found in the temperate regions of both hemispheres, and includes such important cereals as Wheat, Rye, and Barley. These crop plants are the special study of agronomists and will not be considered here. It is of interest that the total number of species for the 8 genera here considered is 171 for the world and 68 for the United States. Of these, the Southwest has 38 species or slightly more than half of all the American representatives, and almost a quarter of the species to be found in the world.

Among the most difficult of the native species to identify are the species of Wheatgrass (*Agropyron*), which are represented in the Southwest by more species than any other genus of HORDEAE. The species of Wheatgrass are widely distributed in temperate regions of both hemispheres, the center of distribution for the United States seems to be Colorado. In the western states where they are widely distributed and often abundant, these

grasses are rated among the very good range plants. Sheep generally prefer the young succulent foliage of these grasses, but will eagerly devour the heads of the unbearded species. Almost all species are continuously palatable to cattle and horses and make excellent winter forage. Deer of the Southwest will graze Wheatgrasses slightly when young and tender, but they, like most game animals, will not touch them when mature.

For many years botanists considered Wheatgrass and Wheat (*Triticum*) as belonging to the same genus. For this reason the older known species of *Agropyron* were placed in *Triticum*. No doubt the resemblance of many of the wheatgrasses to cultivated wheat has led to the common name. This resemblance is also suggested in the scientific name which translated from the Greek means field and wheat. Species of *Agropyron*, however, are readily distinguished from *Triticum* by the narrow, pointed or awned glumes.

For the most part the floral axis of the species of *Agropyron* is continuous, that is, it does not break at the joints. There are, however, three exceptions in which the rachis tardily disarticulates: Spreading Wheatgrass (*A. scribneri* Vasey), Saunder's Wheatgrass (*A. Saundersii* (Vasey) Hitchc.) and Rock Wheatgrass (*A. saxicola* (Scribn. and Smith) Piper). The last two species often have two spikelets per node and the glumes are somewhat bristle-like and prolonged into awns. These are exceptions to the rule in *Agropyron*. None of these species is very common.

Closely related and all too often hard to distinguish from *Agropyron* are the species of *Elymus*, a fairly large genus of usually rather tall grasses of the North Temperate Zone. This genus of grasses is called Wild Rye because of

the resemblance of several of the species to cultivated Rye. It is also known as Rye Grass and Lyme Grass. The scientific name is derived from a Greek word which is an ancient name for a kind of grain. This genus has more species in the Western United States than in any other region. It occurs from the lower semi-desert areas to the aspen and spruce belts.

Generally speaking, the foliage of Wild Rye is harsh and only moderately palatable to livestock. The bearded character of the heads of many of the species renders them undesirable as forage plants during the fruiting season. In general this genus is characterized by having a continuous rachis and two spikelets at the joint of the floral axis subtended by a pair of glumes which are usually subulate and awned and often placed in front of the spikelets.

Among the native genera of HORDEAE in the Southwest is the genus *Hordeum*, from which the tribal name has been derived. *Hordeum* is the ancient Latin name for Barley, which is the most important member of this genus. It has been cultivated since prehistoric times. None of the western species of *Hordeum* have been domesticated, though the grains of *Hordeum jubatum* L. (Foxtail Barley) are used for food by the Shoshone Indians of eastern Oregon.

Closely resembling the species of *Hordeum* are the three native species of *Sitanion* (Squirreltails). Careful observation of the two plants shows, how-

ever, that *Hordeum* has three spikelets at the joint, each of which is 1-flowered and the two lateral two spikelets are on short stalks, while *Sitanion* has only two spikelets at the joint, each of which is 2- to 6-flowered. The beards of Squirreltail Grasses are coarser, rougher, and more bent (divergent) than they are in the species of *Hordeum*.

By all odds the most common of the three native species is Bottlebrush Squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith) an extremely variable species. It and its allies, like many other members of this tribe, are valuable forage plants until the heads appear, at which time the rachis joints are definitely injurious to the grazing animals, causing mechanical injuries by penetrating the mouth, nose, and ears, and working in by the forward movements of the barbed awns.

This is only a brief account of some of the more important genera of this tribe of grasses; much more could and should be said regarding them. Note: Miss Goodding has a key which is available to anyone who might be interested.

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- Hitchcock, A. S., *Manual of the Grasses of the United States*, United States Department of Agriculture, Miscellaneous Publication No. 200, 1935.
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Chapter News Letters

Beta

—University of Michigan

Continuing with its program lectures, Beta Chapter has enjoyed thoroughly the last two talks delivered. On December 4th Dr. Carl L. Hubbs spoke on "Fishes of the Desert." His talk was illustrated by lantern slides made from the photographs he had taken during his expeditions into the desert. The talk was a fascinating one and it led to a group discussion on speciation.

On December 15, Dr. Elzada Clover spoke on "Explorations in and around the Grand Canyon." Her lecture was beautifully illustrated by remarkable colored movies. Since Dr. Clover had lived the entire summer with the Havasupai Indians, the detailed description of Indian life was especially significant.

Beta Chapter has biannually an open meeting in which a speaker outlines the work yet to be done in some biological field. This year Dr. George R. LaRue spoke on "Zoology's Unfinished Business." Before a large audience, Dr. LaRue encouraged research work and said that no branch of zoology was finished business; then he cited specific problems on which work was particularly needed.

Thirty-three new members will be initiated on January 29th.

BETTY M. ROBERTSON, *Secretary*.

Kappa

—University of Kansas

On December 4th, Kappa Chapter initiated the following students: Barbara Jane Owen—Bacteriology; Carl Graham Hoak—Bacteriology; Ronald Leighton McGregor—Botany; Dorothydean Viets—Entomology; Morton Green—Zoology.

Dr. E. B. Stouffer, dean of the Graduate School spoke on "What About Research" at the banquet following the initiation.

Isabelle Baird left the University early in December and was married to James Sprague, December 28th at Fort Knox, Kentucky. Tibby and Jim are now at Cambridge, Mass., where Jim is working on his doctorate in Zoology.

FLORENCE DILL, *Secretary*.

Omega

—University of Oklahoma

At our first 1941 meeting on February 4, Dr. William D. Collings will speak on "The Physiology and Pharmacology of the Adrenal Cortex."

February 8, the officers of Omega chapter are to sponsor a Valentine Day party for the members and the faculty. This party is an annual affair and is to be held at the City Park Lodge.

There are many interesting research papers in preparation here now by graduate members of the society. Some of them are:

Cytological evidences of differentiation in Zebra fish, *Brachydanio rerio*, by Nicolo Austin.

Histological changes in *Scaphiopus Couchii* and *S. bombifrons* during hibernation, by Lillian Clayton.

Morphology and cytogenesis of *Hibiscus esculenta*, by Anna B. Fisher.

Histological studies of the influence of colchicine on the roots of *Allium cepa*, by Reginald O. Hocker.

A Comparative study of the male germinal cells of *Paradalophora sauseri* and *Hippiscus* sp., by Ruth Irby.

The development of the shoot apex and foliage leaves of *Vinca rosea*, by Tillman Johnson.

The ontogeny of the leaf primordia of *Araucaria Bidwilli*, by Marcelotte Leake.

Succession in a bunch grass pasture, by Felton Nease.

The nutritional requirements for the production of green pigments of a fresh-water bacterium, by Dorothy Rainwater.

The effect of growth hormones on the pollen tube penetration of the style, by Frank Rinehart.

Comparative structure, by John Saunders.

Water relations of induced polyploids and related diploids, by Herbert Taylor.

DOROTHY RAINWATER, *Secretary*.

Zeta

—University of Wisconsin

After having such an auspicious beginning for our activities this year in the brilliant address of Dr. Launcelot Hogben, it was only natural to expect that the program committee of Zeta Chapter would continue its fine work. This expectation has been fully justified because at the following meeting, our own Dr. Harold Rusch, Chairman of the University of Wisconsin Cancer Committee gave a brief survey of cancer research with which was coupled a conducted tour of the facilities of the McArdle Memorial Building where this excellent work is being carried on.

Two weeks later, we were addressed by Dr. M. R. Irwin of our Department of Genetics on a "Genetic Analysis of Species Differences in Pigeons and Doves" this being based on the work of the speaker in the field of Immunogenetics.

Then on December 12th, came Zeta Chapter's annual fall banquet held this year in Tripp Commons of our University Memorial Union building. At this meeting new members were inducted and the group was given an insight into certain aspects of mushroom and truffle culture both in this country and in Europe. The speaker on this occasion was Dr. B. M. Duggar of our Department of Botany. His talk was generously illustrated with lantern slides and a remarkable movie of mushroom growth.

Due to Christmas vacation there was no further meeting until January 6th, when the members were again called together at the Memorial Union for a real social evening. This consisted of a bowling party, attended by 27 of the "knock 'em down" enthusiasts. Some made strikes and some made spares and some just made (or didn't quite make) 100 per game. Someone might well beat the high single mark of 219,

but no one could have had more fun and good exercise than we did, including gymnastic demonstrations on the part of several individuals in attempting to outwit the "seeing eye" at the foul line.

A. I. COOMBES, *Editor*.

Alpha Beta

—Mount Union College

News is scarce at the present writing, but we wish to announce that Dr. Max Shaweker, a prominent doctor of Dover, Ohio, gave a most interesting talk on "Heredity" at our last meeting. He illustrated his talk with lantern slides. His talk was outstanding because of the clever presentation of the material.

MERCIEL SMITH, *Corresponding Sec'y*.

Alpha Epsilon

—University of Pittsburgh

Miss Peggy Laschinger has been elected Recording Secretary to replace Mary Theiss, who resigned, to take up work in Washington, D. C.

Mr. Kenneth Wertman was ordered to report to the Carlisle Barracks, Pennsylvania. He will be a Bacteriologist in the Medical Department of the United States Army.

The following members of our society, took part in the program of the American Association for the Advancement of Science meetings held in Philadelphia, during the Christmas holidays.

Dr. E. Alfred Wolf, Maryon Dytche, and John D. O'Neal presented a paper on "Heat Production of Respiring Whole Blood of the Marine Fish, *Tautoga onitis*." Dr. Wolf with Edward Bowser gave a demonstration on "Effect of Sodium Metaphosphate on Growth and Calcification in Mice." Another demonstration by Dr. Wolf was on "A Quantitative Method of Salivary Amylase Activity, Applicable to Group Testing."

"The Effect of Carbohydrates and Inhibitors on Heterotaxia in Chick Embryos" was presented by Dr. Peter Gray, Dr. Mary Dodds, and Helen Worthing. This paper was also demonstrated.

A motion picture and a demonstration were given by Edna Higbee on "Further Effects of Colchicine on Developing Chicks."

Alpha Epsilon chapter is pleased to report that three of its members, Edna Higbee, Peter Gray, and Adolphe DeWerth had writeups in the New York Times during the week of December 31st.

Dr. Lincoln Cartledge, of the University of West Virginia gave an excellent talk on "Human Heredity" at the initiation Banquet held February 14th in the Faculty Club.

The following is the list of initiates: Sarah Dickson Browne; Edgar Lawrence Compton; Arthur Russell Taylor Denues; Mary Marguerite Donovan; Ellen Marian Evans; Rose Solomon Feldman; William Alfred Haley; John William Kelley II; James Kosinski; Elsie M. McClure; Theodore Miller McMillion; John Depp O'Neal; Robert Adams Patton; William McK. Reilly, Jr.; Leonard L. Rock; Robert Hensler Ross; John Karl Russ; Eleanor Louise Saier; Brother Fidelis Thomas Scully; Robert Franklin Stevenson; Robert J. Williamson, Jr.; Margaret Anne Yarett.

EDNA HIGBEE, *Corresponding Sec'y.*

Alpha Eta

—Oklahoma A. & M. College

Alpha Eta Chapter has had several interesting meetings this fall. One evening Mr. DeGruchy gave a fine talk on fish culture illustrated with his own movies of the work at the Blackwell Lake Area. Another time we met with Professor Six of the Geology Department, in his museum and heard an excellent lecture and saw some good films on the effects of volcanic action and erosion.

For our banquet Professor A. D. Buck of Tonkawa served as speaker of the evening and we certainly enjoyed his talk. He is a very energetic and forceful speaker.

ROBERT EALY, *President.*

Alpha Lambda

—University of Utah

Alpha Lambda Chapter has undertaken a new idea in regard to future

meetings. At the first meeting it was decided that the members should be made acquainted with some of the important problems confronting them in graduate work.

In accordance with this idea, another meeting was held. Dr. Flowers of the Biology Department was the guest speaker. His subject was thesis writing. He carefully outlined the procedure in preparation of a thesis and then gave special consideration to the many problems which arise during its construction.

"Your first job," he declared, "is to make certain the problem you are handling is original: obtain all the written material possible concerning your subject, go over it carefully, and if you are then certain you have an original idea, begin your work."

Dr. Flowers stressed the need of compactness and unity, stating that wordiness was probably the most common fault in thesis writing, frequently making it necessary for students to rewrite their work six or seven times. "Such a thing," he declared, "might easily be avoided if given strict attention at all times during the formation of the thesis." He suggested that the material be presented to a committee member for corrections at short intervals. In this way the thesis would develop correctly and concisely and would require little or no change upon completion.

LEWIS NIELSEN, *Secretary.*

Alpha Mu

—University and State College of Oregon

Our chapter is working this year to promote interest in biology by studying biology problems within our State.

Last spring our society decided to give a scholarship, to which an outstanding student of any college or university in the state of Oregon would be eligible. The recipient was permitted to attend the Oregon Institute of Marine Biology at Charleston, Oregon. The student receiving the scholarship completed a rather extensive survey of the tide-pool fish of our area.

This year we have been sponsoring open meetings with the various biology departments on the campus and their

societies. Today we held one with the entomology department. Entomologists from all over our state come in to compare their specimens with those in our College Insectorium.

January 18th Professor C. Anderson Hubbard, addressed our chapter on "Fleas of northwestern America." Professor Hubbard is from Pacific University, and is a well recognized authority on fleas of this country. He was originally interested in rodents and birds, becoming interested in the former subject while studying mammals and their pests.

MAXWELL S. DOTY, *President*.

Alpha Omicron

—Marquette University

Alpha Omicron chapter has worked out a very interesting program for the year 1940-41.

The following is a copy of the events as listed in their program:

October 15th—Robert E. Esser—Marquette University—Incomplete Nuclear and Cellular Division in an Apogamous Fern.

November 19th—James P. Semmens—Embryology of the Albino Rat.

December 10th—Eugene C. Loomis—Marquette School of Medicine—Alcohol in the Living Organism.

January 19th—Open Date.

February 18th—Celemet A. Fox—Marquette School of Medicine—A Method of Producing Localized Lesions in the Brains of Experimental Animals.

March 18th—Herman L. Karl—Marquette University—Chemical Aspects of Phyto-Hormones.

April 15th—Verne Schwalbach—Marquette University—The Origin of Tubers in *Nephrolepis cordifolia*.

May 20th—Kenneth MacArthur—Milwaukee Public Museum—Contributions to the Knowledge of Parasitic Bird Flies.



New Books

Except for the Review of HOPOUSIA, the thumbnail sketches of current biological literature appearing in this section are not meant to be exhaustive or deeply critical. They aim to survey the rapidly growing field of biology. Naturally these reviews represent the candid opinions of various readers not necessarily those of the National Council, nor even those of the editor.

HOPOUSIA, J. D. UNWIN, with an introduction by Aldous Huxley, Oskar Piest, New York, 1940. \$4.00.

The author has attempted to set up an experimental society, which he has called "Hopousia." He has shown that a society is not a collection of individuals, but a network of human groups. In doing this, he discusses the individual and then tries to show the individual's relationship to another individual. These individuals are then placed in groups, which in turn are analyzed, and then placed in the types of groups, which he needed for the purpose of explaining the structure of Hopousia. The mental process, human energy, the cultural process, the structure of a society, and the individual are all analyzed in the first part of the book.

This is followed by a discussion of the Hopousian system as compared with our present day system. The Hopousian system is divided into three parts: political, economic, and social. The present day system is described as being based on Four Economic Follies, in which many of our standards of judgment are reflected, because they are supposed to create the environment into which we are born and pass our whole lives. The parts played by currency, money and commodity-exchange give a background for the discussion of the Four Economic Follies.

The Hopousian structure is analyzed from the standpoint of Sovereign power, the State, Economic structure, Social structure. The social structure includes education and sexual regulations. In all of this it is pointed out that the middle-classes are merely saying, thinking, and doing what has been said, thought, and done many times before. The book ends with the statement that "Human destiny is within

human control. We can take charge of our future if we will."

In reading and analyzing the book one finds that J. D. Unwin had an original and methodical mind, which liked to stress the spiral and undulatory nature of human history, and show that the behaviour of human beings in the mass is determined, even though any given individual may be "free" so far as his individual behaviour is concerned.

E. HIGBEE.

HOW TO KNOW THE INSECTS, H. E. JAQUES, Mt. Pleasant, Iowa. \$1.00, Cloth \$1.80.

A guide for beginners, as well as a valuable reference book for experienced entomologists. It gives full directions for collecting and mounting insects, with many suggestions as to where and how to look for them. Illustrated keys make identification of all the important families easy.

LIVING THINGS—HOW TO KNOW THEM, H. E. JAQUES, Mt. Pleasant, Iowa.

Attractive pictures showing more than 700 different species of plants and animals in its 164 pages. Simple illustrated keys make it easy to trace any plant or animal to its correct Phylum, Class, and Order. Numerous helpful suggestions for collecting and studying living things are included.

STORY OF MICROBES, Second Edition, PAUL WILLIAM ALLEN, John S. Swift Co., Inc., New York. \$3.00.

Told interestingly, simply, and pleasingly for both the orientation of the student beginning the study of microbiology as a part of a profession and the lay reader who wishes to extend his mental horizon, create new and vital sympathies, and become better informed.

BIONOMICS OF ENTOMOPHAGOUS COLEOPTERA AND THE BIONOMICS OF ENTOMOPHAGOUS INSECTS. W. V. BALDUF, *John S. Swift Co., Inc.*

Is the first comprehensive contribution toward an adequate treatment of this phase of entomology. This study brings together the essence of more than 1400 original articles from divers languages and numerous biological journals of the earth. It also provides more than 300 new illustrations and a complete bibliography.

BIRD MIGRATION, A. LANDSBOROUGH THOMPSON, illustrated. *William Salloch, New York.*

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THE PAGEANT OF THE PACIFIC. MIGUEL COVARRUBIAS. *William Salloch, New York. \$9.65.*

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GREAT MOTHER FOREST. ATTILIO GATTI. 1937. *William Salloch, New York. \$1.00.*

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